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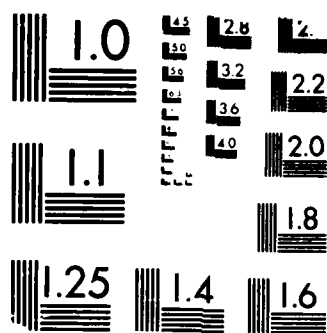   BERKELEY CENTER FOR PURE AND APPLIED MATHEMAT..
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Computer Systems for the Representation and Manipulation of Mathematical Knowledge

12. PERSONAL AUTHOR(S) Richard J. Fateman

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final Report	FROM 3/1/85 TO 8/31/87	2/17/88	4

16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17.	COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

(See page 3 of attached final report)

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22a. NAME OF RESPONSIBLE INDIVIDUAL Richard J. Fateman	22b. TELEPHONE (Include Area Code) (415) 642-1879	22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR   83 APR edition may be used until exhausted.   SECURITY CLASSIFICATION OF THIS PAGE
All other editions are obsolete.
UNCLASSIFIED

FINAL REPORT

1. ARO PROPOSAL NUMBER:- 21719-MA

2. PERIOD COVERED BY REPORT: 3/1/85-8/31/87

3. TITLE: Computer Systems for the Representation and Manipulation of Mathematical Knowledge

4. GRANT NUMBER: DAAG29-85-K-0070

5. INSTITUTION: University of California, Berkeley

6. AUTHOR OF THIS REPORT: Richard J. Fateman

7. List of manuscripts submitted or published under ARO Sponsorship during this reporting period:

Published:

Fateman, R. J. "TEX Output from Macsyma-like Systems," *ACM SIGSAM Bulletin* Volume 21 no. 3 (August, 1987).

   Ponder, Carl G. "Applications of Hashing in Algebraic Manipulation (an Annotated Bibliography)," *ACM SIGSAM Bulletin* Volume 21 no. 4 (Nov, 1987). 10-13.

   Submitted for Publication:

   No new items were submitted for publication during this no-cost extension.

   Accepted for Publication:

Ponder, C. and Fateman, R. J. "Inaccuracies in Program Profilers," (accepted for publication, *Software – Practice & Experience*)

8. Personnel supported and degrees awarded:

   No degrees were awarded during this no-cost extension.

Personnel supported (salary):

   • Carl Ponder

1

- Scott Morrison

- Richard Fateman

The following personnel were supported only through computer access and incidental expenses on the ARO contract.

- David R. Barton

- Manuel Bronstein

- Phillip Colella

- Joseph Landers

- Scott Morrison

- Lilly Spirkovska

9. Brief outline of research findings

During the two-month period under consideration, rearrangement of expressions using divided difference techniques was explored as an extension of work in improving the form of symbolic results of integration programs.

With Scott Morrison, we explored the adoption of of user-interfaces now available on Macintosh workstations as front-ends to more ambitious programs. Ron Avitzur's program, "Milo" is one of the more promising such systems.

Carl Ponder, during this time, primarily supported on other funding continued his studies of parallel algorithms for solution of various problems in algebraic manipulation; a jointly-authored paper on program profilers was accepted for publication.

10. Other notes

There has been no direct substantive contact with Army personnel, or for that matter, ARO, during in this period.

This grant has not been renewed for a third year. This is a report on the no-cost extension to the end of August, 1987, and a final summary report.

Additional information for DD FORM 1473

18: Subject Terms

2

Symbolic mathematics, algebraic computation, computer languages, knowledge representation, programming environments, user interfaces, MACSYMA, interactive workstations

19: Abstract

There have been many attempts to design systems which use computers for the manipulation of symbolic mathematical data. Existing systems begin to provide a useful level of assistance to engineers, applied mathematicians, scientific programmers, and others who must perform large-scale or in other ways tedious symbolic, algebraic computation, accurately, as part of their work. However, systems which are currently available suffer from the fact that they are generally weakly-structured collections of ad hoc programs, and do not have systematic methods for the representation of knowledge (data and algorithms). In some cases, there are fundamental conflicts in being required to deal with notations and manipulations from different contexts. The current implementation strategy for systems consists of developing an efficient core "algebra" system, and tools with which to access it conveniently. These tools include user-programming languages, specialized environments, and graphics interfaces. The goal is to enable a user to deal with the computer and its mathematical knowledge in forms of discourse which are natural for analysis and applications. We used as a core system, parts of the MACSYMA algebra system. Although it would have been preferable in some respects to use a smaller modular system, resources were insufficient to build such programs. During the course of this contract we explored, as specific examples of development environments, a system for exploring conformal mapping, a system for the interactive display and editing of typeset mathematics in the context of MACSYMA, and computer algorithms for the simplification of automatically-produced expressions for purposes of accurate and efficient numerical evaluation. We explored new methods for exact symbolic integration and solution of systems of algebraic equations. We explored the use of parallelism, hash-coding, and other techniques for

Information for Final Report of Inventions and Subcontracts DD form 882

No inventions were produced under this contract. There were no subcontracts under this contract.

The following papers are being submitted with R. Fateman's final report for ARO contract # DAAG29-85-K-0070 entitled "Computer Systems for the Representation and Manipulation of Mathematical Knowledge".

1) Eleven Proofs of $\sin^2 x + \cos^2 x = 1$

2) Comments on SMP

3) The elimination property of Gröbner bases and applications to Computer Aided Design

4) Inaccuracies in Program Profilers

5) A Proposed System to Aid in the Manipulation of Scientific Expressions Arising in Molecular Quantum Mechanics

6) SimPL: A Simulator for Parallel LISP

7) A Review of Macsyma

8) TEX Output from MACSYMA-like Systems

9) Applications of Hashing in Algebraic Manipulation (an Annotated Bibliography)

10) Improving Exact Integrals from Symbolic Algebra Systems

11) On the Systematic Construction of Algebraic Manipulation Systems

12) Algebraic Manipulation Programs -- Why are they? What can they do for you?

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